-continued

wherein $A_\alpha = \sqrt{\frac{\sin\alpha - j\cdot\cos\alpha}{N}}$,

and D is an integer.

[0012] Convolution theorem plays an important role in the signal processing theory based on the traditional Fourier Transform. The fractional convolution theorem is proposed in 1998 by Zayed. According to the definition, the p-order fractional convolution of the signal x(t) and g (t) is defined as:

$$y(t) = x(t)\overset{p}{\otimes} g(t) = \sqrt{\frac{1-j\cdot\cos\alpha}{2\pi}}\cdot e^{-j\cdot\frac{1}{2}\cdot\cot\alpha\cdot t^2}\cdot \int_{-\infty}^{\infty} x(\tau)\cdot e^{j\cdot\frac{1}{2}\cdot\cot\alpha\cdot\tau^2}\cdot g(t-\tau)\cdot e^{j\cdot\frac{1}{2}\cdot\cot\alpha\cdot(t-\tau)^2}\,d\tau \tag{6}$$

wherein $\alpha=p\cdot\pi/2$. In the domain of p-order fractional Fourier, the relationship between fractional Fourier Transform of continuous signals x (t), g (t) and fractional Fourier Transform of continuous signal y (t) which is obtained by fractional convolution of continuous signals x(t)and g (t)is:

$$Y_p(u) = X_p(u)\cdot G_p(u)\cdot e^{-j\cdot\frac{1}{2}\cdot\cot\alpha\cdot u^2} \tag{7}$$

wherein $X_p(u)$, $G_p(u)$ is p-order FRFT of x(t), g(t); $Y_p(u)$ is p-order FRFT of y(t). That is to say, the fractional convolution of two time-domain signals is multiplied by their FRFT of which the product is multiplied by a chirp signal. In the same way, the fractional convolution formula can be obtained in the time domain.

[0013] The fractional convolution theorem is aimed at the fractional convolution of two continuous signals in time domain. However, in engineering practice, processed signals are generally discrete time domain signals. Fractional circular convolution theorem of discrete signals is defined as follows:

$$Y_p(m) = X_p(m)\cdot G_P(m)\cdot e^{j-\frac{1}{2}\cdot\cot\alpha\cdot m^2\Delta u^2} \tag{8a}$$

$$y(n) = x(n)\underset{p}{\overset{N}{\otimes}} g(n) \tag{8b}$$

wherein $y(n)=\mathrm{IDFRFT}(Y_p(m))$, $x(n)=\mathrm{IDFRFT}(X_p(m))$, $g(n)=\mathrm{IDFRFT}(G_p(m))$, and

$$\underset{p}{\overset{N}{\otimes}}$$

n-point is a p-order circular convolution Fractional.

SUMMARY OF THE INVENTION

[0014] It is the objective of the present invention to solve the above-mentioned problem of high PAPR in FRFT-OFDM systems. The present invention provides a low complexity method for reducing PAPR in FRFT-OFDM systems. The method is based on fractional random phase sequence and a fractional circular convolution theorem.

[0015] In the present method, a random phase sequence for PAPR suppression is extended to the same length as that of the FRFT-OFDM signal by way of periodic extension. To effectively reduce the PAPR, the random phase weighted by phase factor is multiplied by the input data before subcarrier modulation, as shown in FIG. **5**. Sum the parallel data of FRFT-OFDM signals in the time domain, and send FRFT-OFDM signals with minimum PAPR to a DAC (Digital to Analog Converter). After modulated by carrier, the signals are amplified by a HPA (High-power Amplifier) and submitted to a transmitting antenna. In this method, the PAPR of the system can be effectively reduced while maintaining the system BER (bit error rate) performance. Low PAPR can increase the output power of the transmitter which is important for mobile terminators like cell phones. When the number of candidate signals is the same, the PAPR performance of the present invention is comparable to that of SLM and better than that of PTS. More importantly, the method of the present invention has lower computational complexity.

[0016] The basic principle of this method is to obtain the FRFT-OFDM signal x(n) in the time domain after digital modulation by performing only one time of N-point IDFRFT calculation. The candidate signals are obtained by making the x(n) chirp periodic extension and circular shift operation, and the results are further weighted. The computational complexity of this method is $O(N\log_2 N)$. This method avoids the parallel computation of multiple N-point IDFRFT as required by SLM and PTS methods, thus lowering the computation complexity.

[0017] The steps of the present method are as follows.

[0018] 1) at a transmitting end of the FRFT-OFDM communication system, perform an N-point inverse discrete fractional Fourier transform (IDFRFT) of digitalized complex input data X of length N and converting it into the time domain to obtain FRFT-OFDM subcarrier signal x(n), wherein n is 1, 2, . . . , N;

[0019] 2) use a multiplexer to perform a p-order chirp periodic extension of the FRFT-OFDM subcarrier signal x(n) to obtain an extended chirp sequence, $x((n))_{P,N}$, wherein chirp refers to a linear frequency modulation and p is the order of Fractional Fourier Transform, and wherein the conversion equation for the p-order chirp periodic extension is:

$$x(n-N)e^{j\frac{1}{2}\cot\alpha\cdot(n-N)^2\Delta t^2} = x(n)e^{-j\frac{1}{2}\cot\alpha\cdot n^2\Delta t^2} \tag{9}$$

wherein $\alpha=p$ and Δt is the sampling interval;

[0020] 3) shift $x((n))_{P,N}$ to the right by iM (i is 1, 2 , . . . , L) points to get $x((n-iM))_{P,N}$, which further multiplies by $R_N(n)$ to obtain chirp circular displacement of FRFT-OFDM signal, $x((n-iM))_{P,N}R_N(n)$, wherein L is the length of the random phase sequence; M=N/L,